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# **Conflict Detection Operational Performance Assessment**

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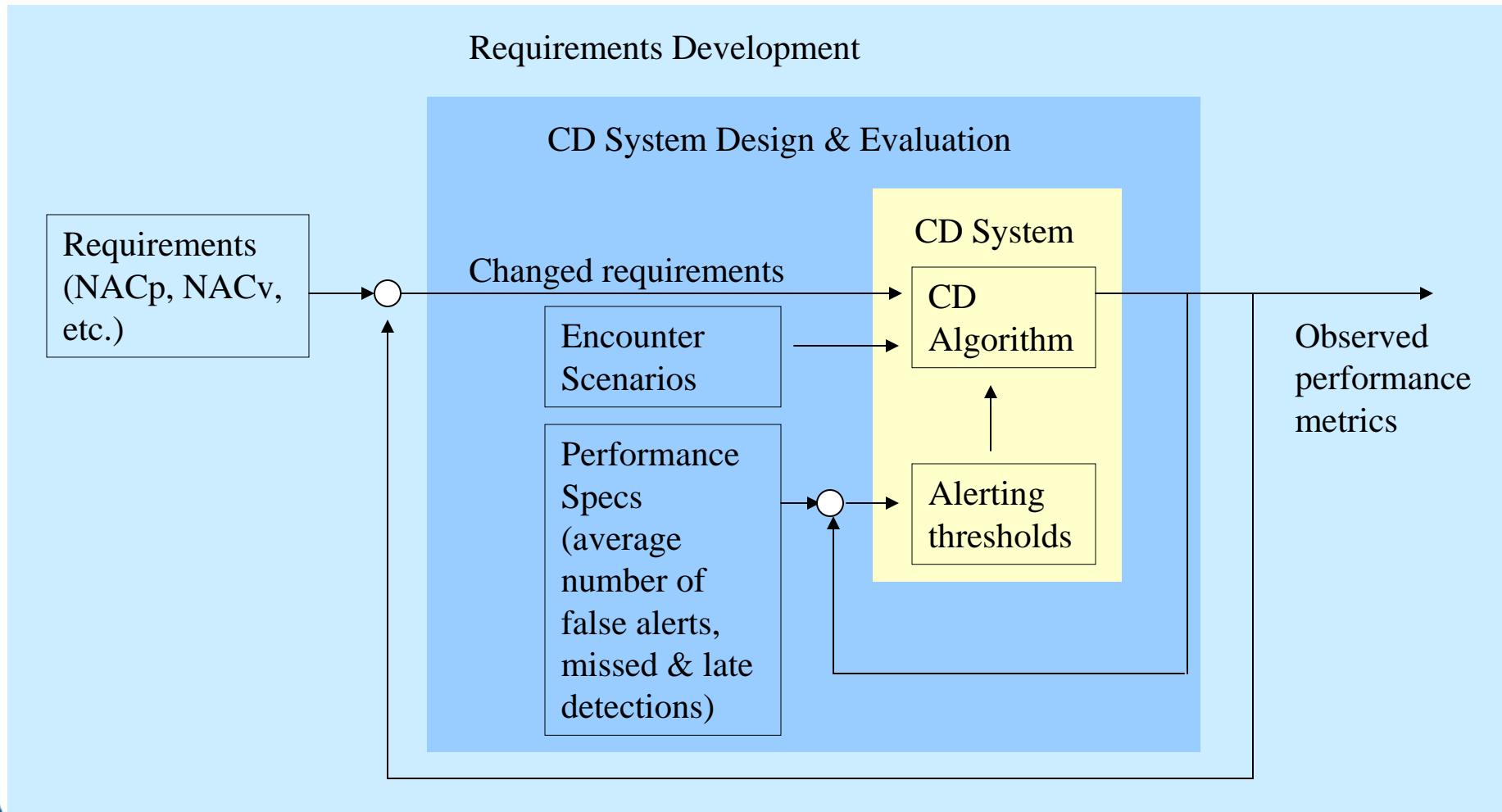


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# Outline

- **CD Analysis Process**
- **Performance metrics**
- **Algorithm**
- **Requirements**

# CD Analysis Process



# Performance Metrics

- **Average duration of false alerts per non-violation encounter**
- **Average number of missed detections per violation encounter**

# Algorithms

- **CAZ – projection of closest point of approach**
  - Alert when thresholds are predicted to be violated
    - TCPA
    - HMD
    - VMD
- **CDZ – project when protection volume will be violated**

# Calculation of estimated HMD, VMD, and TCPA

$dv = |\text{own\_speed\_vector} - \text{intruder\_speed\_vector}|$

$dx = x_{\text{intruder}} - x_{\text{own}}$

$dy = y_{\text{intruder}} - y_{\text{own}}$

$dz = z_{\text{intruder}} - z_{\text{own}}$

$dxd = xd_{\text{intruder}} - xd_{\text{own}}$

$dyd = yd_{\text{intruder}} - yd_{\text{own}}$

$dzd = zd_{\text{intruder}} - zd_{\text{own}}$

where  $xd$  is the  $x$  component of speed

If  $dv > \text{minimum\_attack\_speed}$

then

$$\text{HMD} = (dx * dyd - dy * dxd) / dv$$

$$\text{TCPA} = -(dx * dxd + dy * dyd) / dv$$

else

$$\text{HMD} = \sqrt{\text{sqr}(dx) + \text{sqr}(dy)}$$

$$\text{TCPA} = \text{warning\_time\_thresholdold} + 1;$$

end

$$\text{VMD} = dz + dzd * \text{TCPA}$$



# CAZ

If HMD < horizontal\_threshold and VMD < vertical\_threshold and TCPA < warning\_time\_threshold  
then

```
    conflict_type_CAZ = 2
else if current_horizontal_range < horizontal_threshold and ABS(dz) < vertical_threshold
    conflict_type_CAZ = 1
end
```

# CDZ

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sign_range_rate = dx*dx + dy*dy

if (cur_horizontal_range <= horizontal_threshold) and (ABS(dz) <= vertical_threshold)
    conflict_type_CDZ = 1;
else if HMD <= horizontal_threshold and sign_range_rate < 0. and |dv| > minimum_attack_speed
    t_horizontal_start = MAX(0, TCPA - sqrt((SQR(horizontal_threshold) - SQR(HMD)) / |dv|))
    t_horizontal_end = MAX(0, TCPA + sqrt((SQR(HOR_THRESHOLD) - SQR(hmd)) / |dv|))

    if ABS(dzd) == 0.
        if ABS(dz) < vertical_threshold
            t_alt_start = 0.;
            t_alt_end = 1000.;

        else
            t_alt_start = 1001.;
            t_alt_end = 1001.;

        end
    else if dz/dzd < 0 and ABS(dz) > vertical_threshold // converging and not already violated
        t_alt_start = (ABS(dz) - vertical_threshold) / ABS(dzd);
        t_alt_end = (ABS(dz) + vertical_threshold) / ABS(dzd);
    else if ABS(dz) < vertical_threshold and dz/dzd < 0 // converging & already violated
        t_alt_start = 0;
        t_alt_end = ABS(vertical_threshold + ABS(dz)) / ABS(dzd);
    else if ABS(dz) < vertical_threshold and dz/dzd > 0 // diverging & already violated
        t_alt_start = 0
        t_alt_end = ABS(vertical_threshold - ABS(dz)) / ABS(dzd)
    else
        t_alt_start = t_alt_end = 0
    end
    if t_hor_start < warning_time_threshold && t_alt_start < warning_time_threshold
        if t_hor_start < t_alt_end) and t_alt_start < t_hor_end
            conflict_type_CDZ = 2;
        end
    end
end

```

# Requirements

- **DO-289 ASA MASPS, Section D.2.4**
- **Recommended values**
  - Update period (second): 10
  - Latency (seconds): 3
  - Report time sigma (seconds): 0.4
  - NACp (category): 5 (0.5NM)
  - NACv (category): 2 (horizontal 3m/s, vertical 4.57 m/s)